

6.10. STUDIES ON THE EFFECT OF EARTHWORMS ON THE FERTILITY OF RED-ARID SOIL

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INTRODUCTION

There are 2,030,000 sq/km of red soil in China, which is about 21% of the total farmland. But most of the red soils are not suitable for the growth of crops because of poor fertility. It is intended to raise the fertility level of the red soil and improve the nutritional conditions of crops by adding earthworms and by applying earthworm cast to the soil.

MATERIAL AND METHODS

1. The effect of earthworms on the growth, yield and quality of sugarcane

In this field experiment, four treatments were carried out in the following manner: (1) No earthworms; (2) Introducing 100 earthworms per square metre; (3) 200 earthworms per square metre; (4) 300 earthworms per square metre. Each treatment was repeated three times. The variety of the earthworm was "TaiPin No. 2". Three canes that contained two buds were planted for every square metre. The amount of fertilizers added for each cane was as follows: 4 kg decomposed dung, 0.25 kg ammonium bicarbonate (N 0.035 kg), superphosphate 0.25 kg (P 0.015 kg), 0.1 kg potassium chloride (K 0.05 kg).

2. The effect of earthworm cast on the fertility of red-arid soil

In this pot experiment, the soil used was as that of the field experiment. After drying and passing through a 2 mm screen, 3.5 kg of dried soil was placed in each pot. The experimental design was of a split plot. The earthworm cast treatment (0, 100 and 300 g) were the main plots with five different compositions of chemical fertilizers such as CK, NPK, NP, PK and NK were subplots. The amount of chemical fertilizers used were 0.3 g N, 0.3 g P and 0.15 g K, respectively. Each treatment was repeated three times. Chemical fertilizers and earthworm cast were given as basal manure and mingled with soil in pots where soybean plants were planted. After 75 days of growth, soybean plants were harvested, dried, then the weight of dried plants and nutrient contents were determined.

RESULTS AND DISCUSSION

1. The effect of earthworms on the yield and quality of sugarcane

By introducing earthworms and applying organic manure in the red-arid soil, the structure of the soil and the growth rate of sugar cane improved because of the activity of the earthworms. Table 1 shows the effect of earthworms on sugar cane. The canes in experimental plots with worms were heavier than those in the control plot. The number of the roots also increased with the increase in number of worms.

2. The effect of applying earthworm cast to red-arid soils

The fertility and nutrient levels of red-arid soil were very poor, so all the soybean plants that were treated with chemical fertilizers had the symptoms of nutrition deficiency. Their heights were 20-25% less than those of earthworm cast-applied plots and the number of tillers were 30-80% less. The dry weight of plants treated with chemical fertilizers was 3.8-32.5% more than those of the control. While soybean plants applied with earthworm cast were 50% heavier than those of the control and some of them were twice as heavy as those of the control (Table 3).

The statistical analysis of the dry weights of soybean plants showed that there exists a high significant difference between treatments receiving 100 g cast and the control. While, the difference between treatments receiving 100 g and 300 g cast were also significant (Table 4).

3. The effect of applying earthworm cast on nutrient content of soybean plants and soil

By applying earthworm cast, the fertility of red-arid soil was raised. Table 5 shows that the organic matter in the soil improved from 0.5 to 0.6%, total nitrogen from 0.03 to 0.05%, total phosphorus from 0.093 to 0.121%, total potassium from 0.085 to 0.121%. The available phosphorus and potassium in the soil were respectively 18.2 and 41 ppm more than that of the control. Other elements, including, Ca, Mg and Mo, also increased.

Table 1. The effect of earthworms on sugar cane

Treatment	Cane height (cm)	Cane diameter (cm)	Individual cane weight (cm)	Tillering of each cane (cm)	Effective tillering (%)	Sucrose content (%)	Fresh root weight (g)	amount (number)
control	201	2.8	1.04	5	51.0	16.8	713	142
(1)	215	2.8	1.18	5	51.0	17.0	755	151
(2)	218	2.9	1.37	6	52.5	17.2	768	163
(3)	223	2.9	1.39	7	52.0	17.5	789	167

Note: (1) 100 earthworms/m², (2) 200 earthworms/m² (3) 300 earthworms/m².

Table 2. Effect of earthworms on the individual weight of sugar cane (kg/cane)

Treatment	Mean weight (\bar{X})	$\bar{X}-1.04$	$\bar{X}-1.18$	$\bar{X}-1.37$
(3)	1.39	0.36**	0.21**	0.02
(2)	1.37	0.33**	0.19**	
(1)	1.18	0.14*		
control	1.04			

Significance: 5% L.S.D. = 0.123, 1% L.S.D. = 0.186 level

Table 3. The effect of applying earthworm cast on the dry weight and nutrient contents of soybean plants

Treatment	Earthworm cast (g)	Mean dry weight (g)	Nutritional contents total			Mean absorption (mg/plot)		
			N%	P%	K%	N	P	K
control	0	5.509	2.764	0.121	1.198	152.3	6.7	66.0
	100	8.478	2.320	0.354	2.269	219.9	33.6	215.1
	300	11.661	2.701	0.602	2.820	316.1	70.2	328.8
K	0	7.745	4.390	0.596	2.365	313.7	42.6	168.9
	100	11.348	3.647	1.303	2.806	413.9	147.9	318.4
	300	12.015	3.510	1.900	2.727	421.7	228.2	327.4
K	0	5.720	4.380	0.124	1.802	250.5	7.1	103.1
	100	8.242	3.816	1.240	2.425	314.5	102.2	199.9
	300	10.688	3.456	1.830	2.862	369.4	195.6	305.9
P	0	6.712	4.691	0.747	1.504	314.9	50.1	100.9
	100	9.576	4.245	1.256	2.404	402.3	119.0	227.8
	300	11.316	4.096	1.920	2.652	463.5	217.3	300.1
K	0	7.300	1.946	0.571	2.095	142.1	41.7	152.9
	100	9.319	3.294	1.146	2.117	307.0	106.8	271.8
	300	11.323	4.829	1.821	2.831	546.8	206.2	320.6

Table 4. The comparison of the dry weight of soybean plants among different concentrations of earthworm cast application

Main split treatment	Mean dry weight (X)	X-6.477	X-9.373
300 worm cast	11.401	4.924**	2.028*
100 g worm cast	9.373	2.896**	
no worm cast	6.477		

significant level: 5% L.S.D. = 1.462, 1% L.S.D. = 2.353

Table 5. The effect of applying earthworm cast on the nutrient contents of the soil

Treatment	Organic matter (%)	Total N (%)	Total P (%)	Total K (%)	Avail-able P (ppm)	Avail-able K (ppm)	Ca	Mg	Cu	Mn	Zn	Mo	B	pH
Control	0.55	0.038	0.93	0.085	8.0	60	0.61	0.09	48.3	228	136	2.0	0.52	46
100 g cast	0.61	0.043	0.105	0.105	10.6	72	0.62	0.09	48.0	227	139	2.3	0.51	48
300 g cast	0.63	0.058	0.121	0.121	24.2	101	0.64	0.10	48.1	225	145	3.0	0.49	53

Plant absorbance of nitrogen increased from 30 to 50%. The mean height of the cane reached 223 cm in treatment (3), as compared to the control (no earthworms, the height of the cane was only 201 cm), the height increase was 10.1%. The introduction of earthworms into the red soil not only increased the amount of tillering in each cane, but also increased the effective tillering and the diameters of the canes. The weight of each individual cane increased with the amount of earthworms added. Table 2 shows that there was a significant difference between those soils with 100 earthworms per sq m. and the soils with no earthworms. While, for those with 200 earthworms per sq m. and those with 300 earthworms, the weight of each cane was statistically significant at 0.01 level.

The sucrose content of the cane in different treatments differed. In control, sucrose content was 16.8%, while in treatment (3) the sucrose content reached 17.5%.

As a result of the earthworm activity and secretion, the soil structure was improved and the scope for the development of cane roots increased. Table 1 shows that the average root weight of treatment (1) was 755 g, as a result of the application of earthworm cast. In some of the treatments, it increased by three times. Particularly, the phosphorus content in the plants also evidently increased on applying earthworm cast. The content of phosphorus in the plants grown in plots without cast was only 0.21%, but those with 100 and 300 g cast were 0.354 and 0.602%, respectively. The total amount of phosphorus absorbed by the plants was more than in control, and in some of the treatments it was nine times more than in the control. The amount of potassium absorbed by plants were one to two times more than in the controls. In some of the treatments it was almost four times more than in the control.

SUMMARY

This research concerned with the action of earthworm and earthworm cast on the nutrient release and transformation of soil and plants. By putting earthworms in the red-arid soil, sugar cane grew better, the yield of sugar cane and sucrose increased. By applying earthworm cast the dry weight of soybean plants increased by 40 to 70%. The nitrogen absorbed by the plants from the soil increased by 30 to 50%. Phosphorus and potassium in the plants were twice more than the control. The amount of organic matter, total nitrogen, phosphorus and potassium in the soil also increased evidently, so did the available phosphorus and potassium in the soil.